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**Optimal
Electrocardiography**

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Public Health Service
National Center for Health Services Research

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Abstract

Methodologies established for the computer analysis of the electrocardiogram are rapidly being extended to other physiological measurements such as stress testing, intensive care monitoring, pacemaker calibration, body surface mapping, and echocardiography. To maintain quality control and permit direct comparison of ECG data from these diverse sources, the American College of Cardiology convened a conference to standardize ECG procedures, terminology, and application. The proceedings are summarized as specific recommendations for every discrete part of ECG practice and application; their wide adoption would standardize procedures, terminology, and diagnostic criteria at an optimum level. Particular emphasis is placed on computer applications.

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Optimal Electrocardiography

December 1977

by
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This issue summarizes the findings presented at the Tenth Bethesda Conference on Optimal Electrocardiography sponsored by the American College of Cardiology, Bethesda, Maryland, held April 23-24, 1977. The conference was supported by the National Center for Health Services Research under contract HRA 230-76-0166. Conference papers and the reports of the Task Forces are scheduled for publication by *The American Journal of Cardiology* in February 1978 under the title "Optimal Electrocardiology", available as a preprint.

The authors were co-chairmen of the conference. Dr. Abildskov is Professor of Medicine at the University of Utah Medical Center. Dr. Dreifus is Professor of Medicine of the Jefferson Medical College, and President-elect of the American College of Cardiology.

Other NCHSR publications of related interest include *Demonstration and Evaluation of a Computer-assisted Analysis and Interpretation of the Electrocardiogram* (PB 218 978), a report of a three-year demonstration of a community-wide system for computer-assisted EKG analysis and interpretation carried out by St. Lukes Hospital Association of Denver, Colorado. The report is summarized in NCHSR publication (HRA) 74-3104, *The Computer-assisted EKG from Laboratory to Community*. A one-year, NCHSR-supported study of computer-assisted ECG interpretation and its impact on health care delivery in regional and community hospitals, carried out by Arthur D. Little, Inc. under contract HRA 230-75-0212, is reported in *Automated Electrocardiography in the United States* (PB 257 918).

Current NCHSR publications are listed at the back of this volume. Additional copies of NCHSR publications are available on request from the NCHSR Office of Scientific and Technical Information, 3700 East-West Highway, room 7-44, Hyattsville, MD 20782 (tel.: 301/436-8970).

PB numbers are order numbers for publications available directly from the National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161 (tel.: 703/557-4650). Prices are available on request.

Foreword

This publication demonstrates the fruitful collaboration of the National Center for Health Services Research (NCHSR) and the medical profession in advancing the quality and accessibility of health care through research application. As early as 1969, NCHSR began a series of research, demonstration, and evaluation projects designed to improve the technology and increase the professional awareness of automated electrocardiography. At that time the Medical System Development Laboratory, under the direction of Dr. Caesar Caceres, was nearing completion of ECAN, one of the initial computer programs which permitted on-line analysis of ECG signals. Professional acceptance of ECAN was demonstrated at St. Luke's Hospital in Denver, Colorado, between 1969 and 1972, and reported in NCHSR's publication, *The Computer-Assisted EKG: From Laboratory to Community*. By 1975, NCHSR had disseminated more than 400 magnetic tapes of the ECAN program, and had also provided technical assistance to the requesting institutions to ensure that the program performed as intended. More recently, in 1976, NCHSR supported a major study by Arthur D. Little, Inc., *Automated Electrocardiography in the United States*, which reviewed the diffusion of this innovative technology and analyzed its benefits. Sponsorship of the American College of Cardiology conference, "Optimal Electrocardiography," April 1977, represents NCHSR's most recent effort to ensure professional user participation in the process of demonstrating, evaluating, and deploying new technologies resulting from its research in this field. Under the leadership of the conference co-chairmen, Dr. J.A. Abildskov and Dr. Leonard S. Dreifus, more than 80 cardiologists, engineers, clinicians, and developmental technologists convened to assess the state-of-the-art, identify major constraints, and develop a strategy to help ensure that every citizen has access to a health care system which includes optimal electrocardiography. This publication highlights major findings reported by the conference task forces. The complete reports of the task forces, to be published by *The American Journal of Cardiology* in February 1978, will ensure comprehensive dissemination of these findings.

Gerald Rosenthal, Ph.D.
Director
December 1977

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Conference objectives

Although electrocardiography has been a major laboratory test for more than fifty years, there exists a wide divergency in methodology, terminology, criteria, and professional competence in the use of this most important diagnostic discipline.

With the introduction of computers and computer formats for ECG interpretation, the need for uniform criteria and consensus among clinicians and scientists has become mandatory. Such consensus is especially important as ECG methods are being extended to intensive care monitoring, stress testing, Holter ECG strips for disturbances of cardiac rhythm, transtelephonic monitoring of cardiac pacemakers, body surface mapping, isotope scanning, and correlating noninvasive procedures such as echocardiography.

More than two years ago various scientific groups, recognizing the obvious deficiencies in ECG testing and encouraged by the Engineering Foundation and the National Center for Health Services Research, began to meet and exchange ideas on areas needing study and evaluation. The format of the April 23-24, 1977, Bethesda Conference was to bring together physiologists, clinicians, scientists, and engineers, and representatives of interested groups such as the American College of Cardiology (ACC), the American Heart Association (AHA), the World Health Organization (WHO), and the major service companies that provide ECG systems and analysis. Task groups were established and charged to develop a research agenda and a set of recommendations which might lead toward the practice of optimal electrocardiography.

Standardization

The data base of electrocardiography is probably more diverse than that for any other clinical procedure. Electrocardiographic information embraces areas of anatomy, physiology, and the pathology of heart disease as well as many other organ systems. Included as well are biochemical alterations and changes produced by pharmacologic management. Clinical practice and scientific developments have proceeded independently, sometimes in a rather nonuniform fashion, resulting in a major diversity of ECG nomenclature and criteria. Although optimal criteria have not yet been established for ECG diagnosis of many pathophysiologic states, the Conference recommended the use of standard rules for measurement, classification, and description of ECG features to: (1) improve the consistency and quality of the ECG report, (2) improve communication between the writer of the report and its ultimate user, (3) improve patient care, (4) facilitate the evaluation of different computer programs, and (5) encourage the interchange of information for research and teaching purposes.

Standards must have sufficient flexibility to be applicable to different categories of users, provide for the incorporation of future improvements in ECG diagnosis, and facilitate classification of ECG features from different populations. Special subsets of terms in criteria may be needed for optimal results in specific situations, and the requirements for the performance of certain criteria and the ability to evaluate this performance in relation to information about both sensitivity and specificity are discussed in the Final Report. The terms normal, borderline, abnormal, and atypical are defined, and the preferred terminology and criteria listed. The conference recognized that although the use of standards was advantageous, it was not to be considered as a substitute for individual evaluation and synthesis of clinical ECG information by a knowledgeable clinician.

There are many automated ECG systems in existence and additional variations of formats for display and interpretation can be expected. Ideally, logic, clarity and practicality will supersede historical precedence. Four basic components of an ECG report were identified: (1) demographic data, (2) essential measurements, (3) description of electrocardiographic changes, and (4) interpretation. Demographic data should include identification of the patient and physician, the time and date, as well as the patient's weight, height, diagnosis, clinical status,

blood pressure, and medications. All critical ECG wave form measurements should be listed. The description should list features of the electrocardiographic waveform which are relevant to establishing criteria for interpretation. Finally, the interpretative statements should include rhythm, physician diagnostic statements, comparison with previous records, and comments on clinical association and classification. The conference recommended that the ECG and these basic components of the diagnostics be on the same page so that the ECG is presented in an optimal manner to assist the clinician in patient management. Specific recommendations on lead set arrangements, the duration of the lead set, and format data are described in the Final Report.

Data base requirements

The establishment of protocols and the collection of a large data base are viewed as important prerequisites to: (1) improving existing and defining new ECG criteria, (2) providing support for better standardization of criteria and terminology, (3) improving communication and teaching of physicians and allied health personnel, (4) developing better standards for computer ECG program testing and validation, and (5) promoting collaborative clinical research among institutions by employing compatible techniques in data collection. To meet these needs, the design features of the data base should be specific enough to provide a means to test, validate, and improve ECG diagnostic programs and yet be general enough to encourage basic and clinical ECG research.

The major features of the data base should include: (1) common formats for coding, identifying, and selecting patients; (2) machine readable and retrievable data which are interchangeable among institutions; (3) well defined, objective, quantitative data measurements and recording procedures; (4) minimized variability by limiting subjective impressions; (5) mechanisms for quality control and periodic data review for accuracy and completeness; (6) techniques which assure patient privacy; and (7) data collection techniques which are compatible with other ongoing studies. Three basic types of data were recommended: (1) historical; (2) clinical measurements subdivided for coronary care units, certain laboratory parameters, echocardiography, and cardiac catheterization; and (3) autopsy. A proposed data base format and protocol is described in the Final Report.

The conference recommended that the ECG interpretations be divided into the following categories: Class A Statements—those documented by ECG-independent data such as hypertrophies and infarctions; Class B Statements—those based on ECG-dependent criteria such as arrhythmias and conduction disturbances; and Class C Statements—those which are purely descriptive without implying a specific diagnosis such as axis deviation and certain repolarization abnormalities. The conferees also agreed on the need to establish more objective ECG criteria for cardiac pathology so that basic and clinical research will ultimately provide improved interpretations and comparisons of ECG-independent data with ECG diagnoses. Finally, an ECG-independent data base from several collaborating institutions should be encouraged and the Bethesda Conference, in conjunction with the ECG Committee of the AHA, should seek funding for its support.

Quality of records

The quality of an ECG begins with the skill of the recording technician. Prior experience is not essential, but normal intelligence and interest are mandatory. On-site training is nearly always sufficient and should include developing an ability to identify patient artifacts, recognize ECG lead formats and patterns (especially arrhythmias so that special length and lead sets can be obtained), and understand the basic tests of ECG machines such as the size and shape of the calibration pulse, paper speed, and common artifactual errors. The technician should know how to apply electrodes, prepare the skin, and recognize errors caused by lead reversal. If engaged in computer ECG data acquisition, the technician should also have a basic knowledge of the methods of patient identification, transtelephonic recordings, and the multiple artifacts and errors which may be transmitted back by the computer program.

Although the single channel electrocardiograph is less expensive, the use of three simultaneous channels allows superior interval measurements and permits time-coherent measurement of ECG vectors. Standard instrumentation exists for transmitting either lead systems by telephone or radio. The three channel recording facilitates visual interpretation of the ECG by automatically formatting the record, and is preferred by users who record a sufficient volume of ECGs to justify the higher purchase price. The number of leads recorded for the resting ECG, sequence of lead recording, and nomenclature of the leads should follow AHA recommendations. In children, V4R should replace V4 when automatic machines are used. A conventional 2.5 second minimum for automatically formatted three channel machines, with 7 seconds of continuous recording for rhythm analysis is suggested. Standardization should consist of a 1 millivolt calibration pulse inserted at the beginning or the end of the 12 conventional lead sequence.

A resting control ECG, including the 12 conventional leads, optional or Frank leads, and the lead pattern to be used for recording during and after exercise, should be recorded immediately prior to exercise and interpreted before proceeding with the test. It should be recorded at least two hours after eating, drinking or smoking. The exercise lead pattern should consist of at least two, and preferably three, simultaneous leads. Conventional Wilson V leads are preferred, but if bipolar leads are used, at least one of them should be a CM-5, and other leads

should not share the CM-5 precordial electrode. The ECG should be monitored during exercise by a continuous oscilloscopic display of two or more ECG leads. Hard copy of recordings of at least five seconds duration should be made every three minutes during exercise, at every change of work load, upon the appearance of any significant subjective or objective change in the test subject, and upon the appearance of any significant change in rhythm or QRST contour during exercise. A post-exercise conventional 12 lead ECG should be recorded immediately after exercise in the same body attitude as the control ECG, repeated two to three minutes later, and again four to six minutes post-exercise.

An ECG should be retained for at least five years, and representative waveforms for as long as possible thereafter, with indefinite retention of the interpretation. Storage and retrieval capability should be maintained so that a copy of the ECG, with its interpretation, can be forwarded to other medical facilities. ECG storage on microfilm appears practical, and microfiche jackets offer retention of up to sixty records with inexpensive duplication, easy scanning, and a 24:1 reduction in record storage volume.

Optimal quality of ECG records cannot be achieved without accurate instrumentation for amplifying, transmitting, storing, and display. ECG recorders should meet minimal performance standards developed by the AHA. More recently, as a result of Federal medical/legal device registration, the Food and Drug Administration is also developing performance standards for electrocardiographic devices. The International Electrotechnical Commission has developed similar standards in Europe. The AHA requirements are, with only two exceptions, more exacting than the FDA standards.

The conference reported the two main areas of potential liability associated with automated ECG systems as civil (for malpractice or negligence) and criminal (for unauthorized practice of medicine). One potential liability associated with such systems results when the computer is located in another state, and more legal decisions are needed to develop and clarify this issue. The conferees agreed that any laws enacted should not equate the user of an ECG program to a practitioner of medicine. ECG programs are not yet developed to the point that their use should be considered mandatory in the absence of a local ECG in-

terpreter, and a hospital or clinic should not be considered inadequate in providing health service if it elects not to use a remotely operated computer system.

The conferees recognized that: (1) the FDA has developed minimum standards for certain ECG systems components. These standards will carry the force of the law, and standards for the remaining components will probably follow, and possibly carry the force of law as well. (2) Computer analysis of ECGs should not be considered as the practice of medicine but rather as a system for the distribution of the analysis to health care providers. The interpretation of an ECG by a physician or electrocardiographer in one state may be considered the practice of medicine but the same interpretation distributed to a second state might not be considered the practice of medicine there. (3) Although the transmittal of patient data to an ECG laboratory increases the reliability of the ECG interpretation, such data is private and must be used with discretion so as not to violate the rights of privacy of the patients involved.

The role of computers in electrocardiography

A methodology for program evaluation must be more clearly specified before a meaningful, cooperative comparison of existing ECG programs can be performed. Although no such methodology currently exists, it is mandatory that it include well defined test libraries with appropriate clinical documentation of specific selection criteria for each test group. It is also essential that the dissemination of program comparison results include a description of the methodology used, sample protocols, and specifications for the case selection criteria. The evaluation methodology should measure accuracy, acceptability, utility, and reproducibility, with the acceptability of the ECG statement determined by the reviewing physician, and the utility determined by the convenience, time saving, cost saving, and usefulness of the system in a particular user's environment.

Physicians' offices and hospitals with limited cardiology staffs benefit most from currently available computer-aided ECG interpretation systems. Although the possibility existed for unwarranted utilization of ECG services with the increasing availability of computer-aided interpretation, recent studies report only modest increases following computerization. It was concluded that:

(1) Even though ECG analysis programs and related computer technology are still in the process of rapid development, computerized electrocardiography is effectively being utilized in many medical institutions.

(2) An ECG interpretation by computer is a laboratory test. It may lead to a medical diagnosis after being reviewed by a qualified physician.

(3) The lack of objective reference standards inhibits comparison of the relative merits and shortcomings of the various programs.

(4) The implementation of an ECG analysis program in an environment different from that in which the program was originally designed may produce significant alterations in the program's performance. The conference recommended that comprehensive test methods be developed to verify that translated or transported ECG programs perform in all functional aspects identical to the original version, and that the translator provide documentation verifying the accuracy of the translation.

(5) Substantial differences exist between ECG programs regarding measurement, definition, and classification terminology. While recognizing the importance of diversity for innovation, the conference considered the lack of standardized terminology and definitions a significant impediment to progress. Currently used visual measurement rules and definitions of ECG waves and intervals are too ambiguous to permit reasonable uniform implementation in computer programs. Systematic efforts to produce more persistent and precise ECG measurement rules, definitions and terminology are strongly encouraged.

The scope of the conference did not allow full discussion of the important areas of exercise electrocardiography, monitoring and associated rhythm analysis, interpretation of fetal ECGs, and the application of computers in epidemiological studies. It is recommended that these areas be more thoroughly investigated in the future.

Utilization

A conventional 12 lead ECG is indicated for any patient in whom heart disease is suspected clinically, or who is in a heart disease high risk group. Subsequent ECGs may be indicated to evaluate a change in symptoms or clinical status, or in order to evaluate therapy, but it is uncertain how often repeat ECGs are indicated in those patients with heart disease who are stable. There is also insufficient data to establish an age at which an ECG is justified for asymptomatic persons. Cost factors and the problems of unwarranted anxiety produced by misinterpretation must be considered relative to the value of having a baseline record for comparison upon the appearance of symptoms. Nevertheless, the conference recommended that (1) a baseline ECG be obtained on all adults, (2) routine preoperative electrocardiograms be obtained on all adult patients, and (3) daily or multiple 12 lead ECGs be obtained on patients with acute myocardial infarction until the patient is stable. The conferees cautioned against over-utilization of ECGs in the emergency room, but stressed that all ECGs that are performed in the emergency room should be quickly evaluated by a competent electrocardiographer. An ECG should be obtained on all patients with either penetrating or nonpenetrating chest trauma. Continuous ambulatory monitoring should be used to assess the efficacy of treatment in selective patients with symptomatic dysrhythmias or conduction disturbances. Continuous ambulatory monitoring is also useful in order to evaluate patients with daily or frequent (but not occasional) cardiac or neurological symptoms in order to identify possible occult dysrhythmias or conduction defects. This may be pertinent for patients after myocardial infarction when ventricular arrhythmias are suspected. The role of continuous monitoring is unclear for asymptomatic patients suspected of AV block, bifascicular block, or pacemaker malfunction. Continuous monitoring is not a substitute for an exercise test, nor should it be used for routine evaluation of patients with chest pain or discomfort, since ST changes during such monitoring are unreliable, indicators of myocardial ischemia.

The conferees emphasized the difference between exercise electrocardiography and exercise function or tolerance testing. The value of exercise testing in asymptomatic subjects requires further study. However, exercise may be indicated to evaluate subjects who present an increased community or occupational hazard such as airline pilots,

bus drivers, train engineers, etc. Abnormal exercise responses should not be considered an indication for selective coronary arteriography without other clinical indications. Neither should other costly or invasive procedures be considered to be automatically indicated in asymptomatic subjects. Exercise tests do not usually need to be performed or repeated in asymptomatic patients in the absence of additional clinical indications for the test, such as the development of circumstances implying unusual risk of significant disease.

Competence of the electrocardiographer

Definitive interpretation of the ECG should be performed by a physician. Although subspecialty certification by the American Board of Internal Medicine's subspecialty Board on Cardiovascular Disease cannot be required for all electrocardiographers, physicians who are not certified should show evidence of competence in the interpretation of ECGs. Documentation of formal training is suggested, such as rotation through a cardiology service during residency, and continuing experience in electrocardiographic interpretation. Training programs for primary care physicians, including internal medicine, pediatrics, emergency medicine, and family practice, should include a formal rotation through ECG units capable of providing training and learning experience through supervised interpretation of at least 2,000 ECGs. At this time no recommendation was made regarding the competence of physicians interpreting ECGs on their own patients, but in the future, the same standards should be applied to these physicians as to hospital readers. It is expected, however, that within the next five years, all readers, including pediatric cardiologists, will have to demonstrate their competence by passing a qualifying examination. The testing should emphasize interpretation of ECG tracings, together with basic theoretical knowledge. Because of the rapid changes in the field of electrocardiography, this updating of the knowledge and competence of all electrocardiographers should be periodically reassessed at five year intervals, with physicians completing their residency training after 1977 taking the examination within two years of completing their formal training. The potential for error and misinterpretation of an ECG analyzed by computer is currently such that all interpretations, including those interpreted as normal, must be verified by a qualified reader.

Cost effectiveness

Information concerning the cost of electrocardiography is sparse. With the exception of the Arthur D. Little study* commissioned by the National Center for Health Services Research, cost data are fragmented and represent small populations or unusual circumstances. Cost elements should include personnel, space, supplies, general office materials, equipment, telephone, and miscellaneous items such as insurance, power, heating and indirect costs. Comparisons of single *vs* three channel recorders show that the technician's productivity increases from about 360 ECGs a month with a single channel recorder to 760 ECGs a month with a three channel machine. However, improved efficiency does not result immediately in a decrease in production costs since a minimum number of technician hours are needed to provide an adequate hospital staffing pattern, and the cost of the three channel machine may be six times the cost of the single channel recorder.

Cost data available to the conferees did not show variation on a regional basis. For a 450 bed hospital in the eastern United States, per ECG costs of \$10.39 (\$4.41 personnel, \$2.71 direct expenses, and \$3.27 indirect expenses) were reported. This may be compared to per ECG costs reported by a large teaching institution (\$13.52), and small secondary care facility (\$8.84). In contrast, per ECG costs at the San Diego Naval Regional Medical Center were reduced from \$5.62 to \$4.34 after installation of a three channel machine. Indirect costs, which are not included in figures for three of these hospitals, make it very difficult to compare operational costs from institution to institution since cost accounting methods vary widely. The cost of the physician's interpretation varies according to the type of institution, the degree of abnormality, and the nature of the patient population. All influence the time he requires to interpret an ECG. The cost associated with the interpretation of an ECG by an "expert" is, however, generally higher than these of other categories of physicians.

The cost of purchasing an in-house computer system ranges from \$100,000 to \$225,000, and per ECG processing costs approximate

\$4.25 (1,000 per month), \$2.25 (2,000 per month), and \$1.50 (3,000 per month). Health facilities implementing a new processing system should cost analyze all available options to assure that the new process is the least costly approach to providing the desired service. Cost, however, is not the only factor to be considered. Less tangible benefits of computerization may prove to be overriding factors for some institutions.

*** "Automated Electrocardiography in the United States"; Contract HRA 230-75-0212; National Center for Health Services Research, PB 257918.**

Future directions

Increased use is likely for body surface mapping, direct cardiac mapping, intracardiac electrocardiography, continuous electrocardiographic monitoring, signal averaging, magneto electrocardiography, and stress testing. Promising research is in progress to achieve (1) refinement of recording techniques recommended for body surface mapping with the optimal number of leads, (2) rapid data processing procedures with small computers, and (3) the display of the potential distribution on movie film to make the maps readily available and easily viewed by the physician. Especially promising will be the use of QRS, T, and QRS-T iso-area body surface maps. A representation of cardiac electrical activity as derived from body surface maps will provide an important clinical tool as an extension of conventional electrocardiography. In essence, the recording of body surface mapping is the use of limited lead systems to record body surface maps during ischemia induced by exercise or pacing. The equivocal diagnosis of myocardial infarction should be explored with body surface maps. Finally, body surface maps should provide improved ways to more accurately localize the site of origin of anomalous sites of activation such as occur in WPW and ventricular arrhythmias.

Newly developed programs for computer-assisted arrhythmia detection and diagnosis will result in increased utilization of continuous ECG monitoring, and bring even greater pressure to develop program comparison methodologies. The present programs have not yet been validated as to accuracy and reliability. Methods for data storage other than magnetic tapes need additional exploration. The use of microprocessors or large scale integration components will encourage further data reduction such as coding or simplification of the wave forms before storage, or preselection of data for storage. Such technological advances will allow prolongation of the monitoring period and reduction in size of the recorders, making it possible to record more leads and obtain some of the advantages of body surface mapping. The application of signal averaging to ST-T waves of the TP segment will allow detection of delayed activation of diseased ventricular myocardium. Delayed activation potentials might serve as an indicator of serious ventricular arrhythmias, a guide to antiarrhythmic therapy, a diagnostic aid in the detection of heart disease, or provide the means to differentiate between reentrant and automatic ectopic beats.

Future research into magnetocardiography will facilitate measurement of "currents of injury" which are manifested by ST and TP segments shifts of the surface ECG. Stress testing has already been combined with myocardial imaging to better define the presence and severity of myocardial ischemia and myocardial dysfunction. In the future, body surface mapping techniques will allow recordings during dynamic exercise. Finally, further study of surface potential electrocardiography and investigation of cardiac conduction and arrhythmic disturbances represent major research areas which show promise. They will add to the knowledge data base and give the clinician the armamentarium necessary to practice optimal electrocardiography.

The goal, optimal electrocardiography, cannot be achieved by holding one conference or by disseminating the Task Group Reports and publication of the proceedings in the American Journal of Cardiology. What is important is that the collaboration initiated by the conference among the clinicians, researchers, service vendors, and professional associations continue, and that it serves to promote a more rational and unified approach to resolving current inadequacies and divergencies in the delivery of electrocardiographic services. Towards this end there is a strong commitment by members of the various task groups to continue the work of the conference, especially in the areas of terminology and criteria standardization, the development of a common data base, methodologies for program comparison, and core curriculum and physician competence. Most of the technology needed to implement these methodologies is already available and awaits only judicial application of health care resources such as those represented at the conference.

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- (HRA) 77-3167 Emergency Medical Services Systems Research Projects (Active as of June 30, 1976) (PB 264 407, available NTIS only)
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